SIMULATION STUDY ON BEHAVIOUR OF REINFORCED CONCRETE BEAM WITH VARIOUS SIZING AND SHAPE OF OPENING IN SHEAR ZONE

CHONG KHANG ZEN

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

_____

(Supervisor's Signature)

Full Name : MOHD ARIF BIN SULAIMAN

Position : Lecturer

Date : 11 June 2018

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

_____

(Student's Signature)

Full Name : CHONG KHANG ZEN

ID Number : AA14178

Date : 11 June 2018

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ABSTRAK

Setiap bangunan perlu memasukkan paip dan saluran untuk pemasangan perkhidmatan mekanik dan elektrik. Dengan membuat pembukaan pada rasuk konkrit bertetulang boleh memberikan laluan untuk memasang semua paip dan saluran tersebut. Walau bagaimanapun, kesan pembentukan bukaan pada rasuk konkrit bertetulang perlu dipelajari untuk mengelakkan kegagalan rasuk. Tujuan kajian ini adalah untuk menentukan kesan pelbagai saiz pembukaan pekeliling dan bentuk pembukaan yang berbeza pada zon ricih konkrit bertetulang bertulang dari segi beban muktamad, pesongan dan retak. Ansys 12.0 digunakan dalam kajian ini untuk mensimulasikan ujian pemuatan 4 titik pada sejumlah 6 rasuk. Satu rasuk konkrit bertetulang pepejal yang dinamakan RCB S. Tiga rasuk yang mempunyai diameter pembukaan pusingan diameter yang berbeza iaitu 60mm, 80mm dan 100mm, yang dilabelkan sebagai RCB 1, RCB 2 dan RCB 3 masing-masing. Rasuk 2 yang lain dengan pembukaan segi empat tepat dan pembukaan persegi ditetapkan sebagai RCB 4 dan RCB 5 masing-masing. Saiz pembukaan bentuk pembukaan yang berbeza bersamaan dengan saiz pembukaan pekeliling 100mm. Semua rasuk mempunyai bahagian silang yang sama 120mm X 300mm X 2000mm dan susunan tetulang tidak berubah. Berdasarkan hasilnya, kemasukan pembukaan pekeliling dengan garis pusat yang lebih besar daripada atau sama dengan kedalaman rasuk 0.27 akan mengurangkan kapasiti muatan akhir dengan sekurang-kurangnya 21% sementara pesongan pertengahan rentang menurun sekurang-kurangnya 64%. Di samping itu, dalam kajian ini, bentuk optimum bagi pembukaan adalah pembukaan segi empat tepat kerana ia mempunyai beban muktamad tertinggi. Walau bagaimanapun, bukaan dengan sudut tajam menyebabkan tekanan tertumpu di kawasan yang menyebabkan keretakan awal berlaku. Kesimpulannya, diameter pembukaan pekeliling yang kurang daripada atau sama dengan kedalaman 0.2 rasuk akan tetap menjadi tingkah laku rasuk konkrit bertetulang pepejal.

ABSTRACT

Every building need to include pipes and ducts for the installation of mechanical and electrical services. By creating an opening at the reinforced concrete beam can provide a passage to install all of these pipes and ducts. However, the effects of creating an opening at the reinforced concrete beam have to be studied in order to prevent the failure of the beam. The aim of this study is to determine the effect of various size of circular opening and different shapes of openings on the shear zone of reinforced concrete beam in terms of ultimate load, deflection and cracking. Ansys 12.0 was used in this study to simulate 4 point loading test on a total of 6 beams. A solid reinforced concrete beam named as RCB S. Three beams with different size of circular opening in diameter which is 60mm, 80mm and 100mm, labelled as RCB 1, RCB 2 and RCB 3 respectively. The other 2 beams with rectangular opening and square opening designated as RCB 4 and RCB 5 respectively. The opening size of different shapes of opening was equivalent to the size of a 100mm circular opening. All beams have identical cross section of 120mm X 300mm X 2000mm and the reinforcement arrangement unchanged. Based on the result, inclusion of a circular opening with diameter larger than or equal to 0.27 of the beam depth will reduce the ultimate load capacity by at least 21% while the mid-span deflection decrease by at least 64%. Besides that, in this study the optimum shape for opening is rectangular opening as it has the highest ultimate load. However, openings with sharp corners causes stress to be concentrated at the area which leads to early cracking to occur. In conclusion, the diameter of circular opening less than or equal to 0.2 depth of the beam will remain the behaviour of a solid reinforced concrete beam.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In the structure of a building, reinforced concrete beam plays an important role in transferring the load. It is a horizontal member of a structure which carries transverse loads from floor slab or roof slab which then transfer all the loads including its own self weight to the columns or walls. Beams can have different type of supports such as simply supported beam, fixed beam, cantilever beam and continuous beam. The type of support we will be using for this research is simply supported beam. Nowadays, the construction of modern building requires to include a lot of pipes and ducts for the installation of essential services such as air conditioning, electricity, network cables and water supply system. Creating an opening in reinforced concrete beams can provide a passage to install all of these pipes and ducts. The routes of the pipes and ducts are usually located underneath the beam soffit which will then be covered by a suspended ceiling for aesthetic reason, thus creating a dead space (Mansur, 2006). The dead space will increase the storey-height which will also contribute to the total height of the building. Therefore, installation of pipes and ducts through the opening in reinforced concrete beam can reduce the height of the dead space and leads to a reduction in the total height of the building. Besides that, the weight of concrete beam will also be slightly reduced, thus allowing the designer to produce a more economical design. For a construction of a low-rise building, the cost saving might not be as significant as a construction of a high rise building. This is because that for a high rise building, any reduction in the storey-height are multiplied with the total number of stories of the building which will result in major cost saving.

Most of the time, structural engineers will place the opening at areas that can avoid the beams from losing its original properties. Mansur & Tan (1999) states that in

order to avoid the critical region for shear failure, openings should not be placed closer than one-half of the beam's depth, D to the supports and avoid placing openings closer than 0.5D to any concentrated load. However, there are situations that the opening will be required to create at critical region where shear is the main concern in order to simplify the installation and arrangement of the pipes and ducts. In the shear zone of a beam, the beam experiences greater shear load which tends to have a greater tendency to produce a sliding failure on a material along a plane that is parallel to the direction of the force. The creation of opening in shear zone will cause discontinuity in the normal flow of stresses which will lead to greater reduction of the beam shear capacity and stiffness of beam. As the opening depth or size increases, the greater the reduction in shear capacity of the beam. The reduction of shear capacity will be more significant when the opening is located at the line connecting the load and support points (Jithinbos et al, 2016).

Opening can be classified into pre-planned and post-planned. Post-planned openings are known after the structure have been constructed. It will involve drilling to create an opening at the existing structure. This might be risky because the opening might locate at areas that will affect the reinforcement or affect the behavior of the structure. Pre-planned openings are better than post-planned opening because the shape, size and location are known in advance during the design stage for pre-planned openings. Thus, designer can take the opening into consideration during the designing stage and provide proper reinforcement for the opening to ensure that sufficient strength and serviceability of beams with opening. In addition, opening in beams may come in different types of shapes such as circular, rectangular, triangular, diamond, trapezoidal and even irregular shapes (Prentzas, 1968). Although there are a variety of shapes available for opening, circular and rectangular openings are the most common shape being used in construction. Circular openings are normally for the passage of service pipes such as plumbing, network cables and electric while rectangular openings are required to provide passage for air-conditioning ducts (Mansur & Tan, 1999). However, opening shapes that consist of sharp corners are required to be rounded off to reduce the stress concentration at sharp corners and reduce the possibility of cracking at the sharp corners. In terms of the size of openings, many people use the term small and large to differentiate the size of opening because there are no standards that can be used to define the size of opening. According to Mansur & Tan (1999), classification of small and large opening based on the structural response of the beam. When the opening is small enough to maintain the solid beam

behaviour, the opening can be classify as small opening. When the beam fails due to the opening, then the opening can be classify as large opening.

1.2 Problem Statement

Nowadays in the field of construction, reinforced concrete beams are frequently required to create a web opening in it to allow the passage for utility services such as pipes and ducts for the air-conditioning, water supply system, electricity, and telecommunication and computer network cables. Usage of reinforced concrete beams with opening for construction projects has increased significantly due to the convenience and economic considerations, especially for high rise building because opening in beams enable the designer to reduce the total height of the whole building. Circular opening can be classified as small or big opening which is normally differentiate using depth-to-diameter of the opening. Besides that, opening can also come in different type of shapes but the common shape of opening used in construction is the circular and rectangular. Figure 1.1 and Figure 1.2 shows the reinforced concrete beam with opening.

Figure 1.1 Beam with Opening

Figure 1.2 Beam with Opening

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